

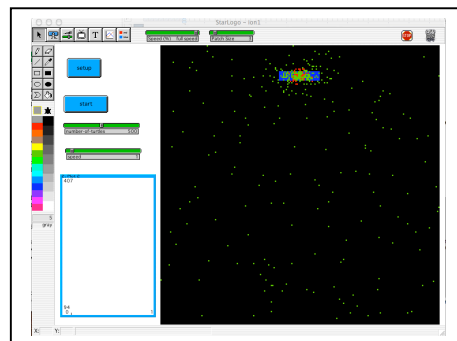
Simulated Ion Development

Time:

30 minutes

Objective:

Through a 'Starlogo' simulation (modeling), students will develop an understanding of the differences between a model and real life.



Teacher note

This is a simulation where the students can modify some of the parameters, but this is more of a demonstration and should be used in conjunction with lecture and hands on experiments. Advanced students are welcome to investigate the programming in the Starlogo models. They may modify the programs to make the simulation more real.

Content Standards:

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry
 - Identify questions and concepts that guide scientific investigations
 - Design and conduct scientific investigations
 - Use Technology and Mathematics to improve investigations and communications
 - Formulate and revise scientific explanations and models using logic and evidence
- Understandings about scientific inquiry
- Physical Science – Content Standard B
 - Structure of atoms
 - Structure and properties of matter
 - Motions and forces
 - Conservation of energy and increase in disorder
 - Interactions of energy and matter

Equipment, Materials, and Tools:

- Computer with Starlogo downloaded from: <http://education.mit.edu/starlogo/>
- The Starlogo code file (ion1.slogo) is included in the Appendix section

Background Information:

An ion is a charged particle formed from a neutral particle by the addition or subtraction of one or more electrons. The word was coined by Michael Faraday and comes from the Greek word meaning “wanderer.”

Plasma, such as the plasma found in stars, consists of electrons and bare nuclei. The plasma then contains a swirling mass of positive ions and electrons. Although the ions themselves are charged, the plasma as a whole has no charge. It contains as many positive charges as negative charges. The main difference between a gas and plasma is that plasma can conduct an electric current while a gas cannot.

Since 1949, scientists have assumed that ions in plasma must achieve a velocity known as the ion-sound, or Bohm, velocity before they flow out of the plasma. Back then, academic and theoretical physicist David Bohm showed that the ions must drift at a certain velocity based on

electron temperature and ion mass—even if the ions have a zero temperature in the bulk plasma.

But what scientists didn't know is how the ions sped up. Bohm suggested it was the result of weak electric fields that formed in the plasma away from the thin boundary, or sheath, at the plasma's edge. Normally, that sheath is positively charged, while the rest of the plasma is electrically neutral.

In the theoretical literature describing the phenomenon, Professor Noah Hershkowitz says the region in which ions are accelerated is often called the presheath.

Although determining the details of the plasma potential profile near boundaries is one issue critical to basic understanding of confined plasmas, until recently, no one had experimentally verified Bohm's theory and subsequent models of presheaths.

In a fusion device, loss of plasma at a limiter or diverter determines both the heating and particle recirculation at that point and provides basic limits as to how much current researchers can extract, what density level they can achieve, how long materials last, and more. The details of what happens near the sheath can determine what happens to a satellite in space: what the electric fields near the satellite look like, when particles are emitted by photoemission or by interaction with the surroundings, how that plasma is lost and so on. Understanding what's going on is an important thing to do.

Instructions:

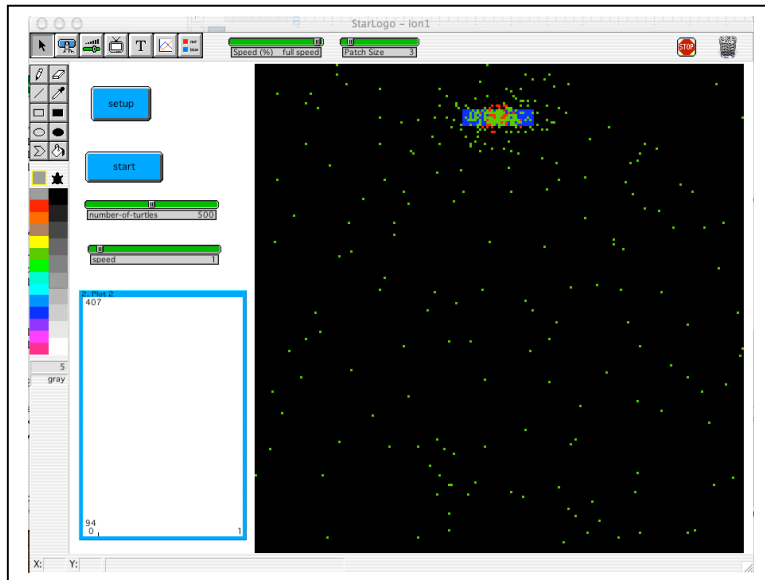
1. Download and install StarLogo software from <http://education.mit.edu/starlogo/> on your computer.

StarLogo is a programmable modeling environment for exploring the workings of decentralized systems -- systems that are organized without an organizer, coordinated without a coordinator. With StarLogo, you can model (and gain insights into) many real-life phenomena, such as bird flocks, traffic jams, ant colonies, and market economies.

In decentralized systems, orderly patterns can arise without centralized control. Increasingly, researchers are choosing decentralized models for the organizations and technologies that they construct in the world, and for the theories that they construct about the world. But many people continue to resist these ideas, assuming centralized control where none exists -- for example, assuming (incorrectly) that bird flocks have leaders. StarLogo is designed to help students (as well as researchers) develop new ways of thinking about and understanding decentralized systems.

StarLogo is a specialized version of the Logo programming language. With traditional versions of Logo, you can create drawings and animations by giving commands to graphic "turtles" on the computer screen. StarLogo extends this idea by allowing you to control thousands of graphic turtles in parallel. In addition, StarLogo makes the turtles' world computationally active: you can write programs for thousands of "patches" that make up the turtles' environment. Turtles and patches can interact with one another -- for example, you can program the turtles to "sniff" around the world, and change their behaviors based on what they sense in the patches below. StarLogo is particularly well-suited for Artificial Life projects.

2. Start StarLogo. Select File, Open Project and select "ion1.slogo" (you must copy the program code from the Appendix and save as "ion1.slogo." From the "Windows" select tool, select "Interface." You should see the following screen:



You can set the number of 'Turtles' and the 'Speed' at which they move with the set-up button. The blue rectangle represents a magnet.

This simulation sheds some light on ion creation. Green turtles, representing the non-ions, will randomly wander around. When they hit each other they turn into a Red turtle, an ion. These ions are then attracted to the blue magnet at the top of the screen. Once the Red turtles (ions) hit the blue magnet, they turn back into Green turtles (non-ions). One point of

this simulation is the relative amounts of ions to non-ions depending on the total amount of turtles and the speed.

Assessment:

Have students explain the difference between a model and real life, how the model is not a perfect representation of reality.

Questions:

What would happen if you increase the initial number of particles? What happens to the display graph?